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Bringing the Classroom to the Web: Effects of Using New Technologies to Capture and Deliver Lectures

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Abstract Technology expands instructional options for faculty, and this study examines the differential learning effects of offering a lecture on physics to students in a traditional classroom versus internet video formats. Based on an experiment conducted in a natural educational context, results indicate enhanced transfer of lecture information in the video formats relative to the live condition, with students also responding more positively to personalized video presentation.

Keywords College students · Learning · Instructional technology · Distance learning · Lecture capture

President James A. Garfield once remarked that the ideal college education was Mark Hopkins, President of Williams College, on one end of a log and a student on the other (Rudolph 1956). With the advent of electronic mail, the World Wide Web, and video-conferencing technologies, that ideal can be morphed into a virtual Mark Hopkins writing a blog, with geographically dispersed students co-constructing it via a web interface.

Today, college students' computer expertise often exceeds that of their professors (Tapscott 1997). They arrive on campuses ready to engage information in new ways, only to find faculty who are reluctant to alter their traditional and entrenched teaching approaches. Duderstadt (2000) argued that this digital generation would soon be

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demanding more interactive instruction, forcing colleges and universities to publish information in forms accessible through various devices. Campuses have responded by offering administrative material via cell phone, packaging and distributing course content via PDAs, and offering various content through new Podcasting technologies (Crofts et al. 2005). Such demands will challenge institutions and their faculty members to continuously rethink the role of technology in instruction—even as market and policy changes are redefining postsecondary education.

Existing research on faculty adoption of teaching technologies shows a range of responses that spans stubborn resistance to eager early adoption. Studies directed at explaining this range of adoption reveal that instructional use of technology is multi-dimensional, involving interplay between faculty attitudes (Baldwin 1998; Paloff and Pratt 2001), professional characteristics (Corwin and Marcinkiewicz 1998), perceptions of the value of technology (Massy and Wilger 1998; 'An Online Experience' 1995), and institutional factors (i.e., reward structures, classroom infrastructures, institutional IT resources) (Grunwald 2004; Walburton and Chen 2002; Mitra et al. 1999; Gibson and Nocente 1998; Jacobson 1998; Knutel 1998). It is also important to remember that decisions to use technology in instruction are embedded in the personal epistemological beliefs of individual faculty (Hofer and Pintrich 1997), and that these beliefs guide the decisions faculty make about learning outcomes for their students, and the methods they believe will be most effective in achieving those outcomes (Stark and Lattuca 1997). Thus, resistance to the use of technology in teaching may not reflect actual technology concerns, but rather a more diffuse and deeply entrenched set of beliefs and practices (Paulsen and Feldman 1995) and general trends in teaching practices (Trice and Dey 1997).

Some level of guidance or assistance for faculty interested in using technology is available at most institutions, which underscores the belief that technology can be effectively used for instructional purposes (Bransford et al. 1999). While general guidance is plentiful, the evidence-base on the educational consequences of specific technology applications on college student learning is, however, neither large nor readily accessible to faculty seeking to make decisions about the kinds of outcomes they might expect from the deployment of different technologies in the classroom.

The goal of this study is to provide empirical evidence linking specific learning outcomes with the use of technology in education. Cognitive design principles for creating *multimedia instructional messages* (or presentations) (Mayer 2001) were used to develop and explore the effects of different presentation modes on student learning outcomes, such as retention of material and transfer of information to new settings. As used here, multimedia refers to information being presented in two or more perceptual modalities (e.g., visual and auditory). While proficient instructors may develop skills that make use of such principles without articulating them specifically, it is useful to explicitly model and test such principles to guide faculty activity and development efforts.

We sought to understand technological factors that influence learning, with specific focus on differences in learning related to seeing an image of a lecturer in a multimedia presentation. While previous research on this topic has been conducted in laboratory settings, this study was conducted as a field-based clinical trial and seeks to examine these issues in the more natural context provided by an undergraduate physics course at a large, selective research university. Intended as a building-block toward more generalizable efforts, this study also intends to inspire additional research connecting traditional higher education scholarship to efforts connecting research to practice through the development of approaches commonly known as the scholarship of teaching and learning (Huber and Hutchings 2005).

Conceptual Framework and Supporting Literature

A recent ASHE-ERIC Higher Education Report, *Quality in Distance Education: Focus on On-line learning* (Meyer 2002), encourages the application of cognitive theory from the field of multimedia learning to research on web-based education. *Multimedia learning* is learning from pictures (e.g., video, animation, graphics, or illustrations) and words (e.g., printed or spoken words). The report states, “The relationship of multimedia learning to the Web is not so far removed as one might expect, as both use visual, auditory, and text-based communication” (Meyer 2002, p. 27). *Multimedia learning* is when information is presented simultaneously in two or more formats, such as words and pictures (Mayer 2001). One essential element in cognitive theories of learning is cognitive load theory (Sweller 1994). Cognitive load refers to the “total amount of mental activity imposed on working memory at an instance in time” (Cooper 1998, p. 11). Cognitive load theory, then, is primarily concerned with the limitations of working memory and views the “limitations of working memory to be the primary impediment to learning” (Cooper 1998, p. 31).

Drawing on Sweller’s cognitive load theory, Mayer (2001) developed a cognitive theory suggesting that multimedia learning can be created in way that leads to a reduction in cognitive load and optimizes the use working memory. Mayer’s theory is based on three assumptions: the dual channel assumption (Paivio 1986; Baddeley 1992), the limited capacity assumption, and the active processing assumption (Baddeley 1992; Chandler and Sweller 1991). The *dual channel assumption* is that humans have partially separate visual and auditory channels for receiving and processing information, effectively allowing distinct, multiple inputs that do not inherently conflict with one another. The alternative is to assume that all information enters the cognitive system through a single channel regardless of modality. The *limited capacity assumption* is that there is a limit on the amount of information we can process in each channel at any one time. The *active processing assumption* is that humans are active processors seeking to make sense of multimedia presentations.

A well-established concept in cognitive science is that learners apply *cognitive processes* to make sense of incoming material. Mayer believes that multimedia learning occurs when learners engage in different kinds of cognitive processing: selecting words, selecting images, organizing words, organizing images, and integrating these elements. In selecting words and images, humans transfer externally presented visual or verbal information from *sensory memory* into *working memory*. Once in working memory, learners organize this selected material into a coherent representation or model, such as a process, comparison, generalization, enumeration, or classification (Chambliss and Caffee 1998; Cook and Mayer 1988). By integrating, we create connections between new knowledge and stored knowledge. This involves bringing stored knowledge from long-term memory into working memory, which can be further enhanced by following a number of *design principles* derived from this theoretical perspective (Mayer 2001; Table 1). Mayer used his cognitive theory of multimedia learning to develop seven design principles intended to increase retention and transfer of material. All seven principles have a strong theoretical and empirical rationale, and are drawn from the assumption that learners have separate visual and auditory channels receiving and processing information (which allows distinct inputs to not be in conflict with one another), have limited ability to process incoming information, and that that humans are active processors seeking to make sense of multimedia presentations.

Mayer’s design principles are significantly influenced by a notion called the *split-attention effect* (Sweller et al. 1990), which occurs when students attend to more than one

Table 1 Overview of Mayer's design principles

Principle	Basis
Multimedia	Words and pictures work better than either alone
Spatial contiguity	Words and pictures should appear close to one another
Temporal contiguity	Simultaneous appearance of words and pictures
Coherence	Extraneous words and pictures
Modality	Animation and narration are better than animation and text
Redundancy	Animation and narration (e.g., not animation, narration and text)
Individual differences	Design with differences in mind (low knowledge learner versus high knowledge learners and high spatial learners versus low spatial learners)

source of information or more than one activity, such as graphics and text, because neither alone provides sufficient information for understanding (Cooper 1998). This inspired development of Mayer's spatial and temporal contiguity principles. Basically, when individuals split their attention between two sources of information, the portion of working memory required to integrate the two sources is unavailable and learning is ineffective. This effect was demonstrated in an experiment where scholars were reading research papers with separate results and discussion sections that needed to be integrated in order to understand the results and their implications (Chandler and Sweller 1992).

Attention splitting can also be an issue when multimedia presentations include "on-screen agents" to help guide student learning. The inclusion of onscreen agents in multimedia presentations is premised on the assumption that people prefer relating to and communicating with other people, which is one reason why many anthropomorphize their computers (Laurel 1997). There is also a "social-cue hypothesis" (Rutter 1984), which asserts that the outcome of most communications would be more effective if they contained more natural social cues. In multimedia presentations, social cues are sometimes provided by a pedagogical agent, such as an animated cartoon character or, in the case of this study, a video image of the actual physics instructor. Kiesler and Sproull (1997) found that individuals were more likely to cooperate with an agent that had a human face rather than a cartoon. The presence of a lifelike character, even one that is not very expressive, has been shown to have a positive effect on learners' interactive experiences (Lester et al. 1997). Lester et al. (1997) called this the *persona effect.*

Although the learning effects of on-screen personas have been mostly explored with animated characters, the visual presence of an instructor in a multimedia presentation effectively mimics the experience learners have had throughout their education, and thus help reduce instructional load and increase learner motivation and attention by modeling the kinds of interactions that occur within various education settings (Andre et al. 1998; Lester et al. 1997). However, results are mixed with respect to whether the presence of an on-screen agent creates a split-attention effect that hinders learning. For example, Andre et al. (1998) showed that students enjoyed the learning experience more when an agent is included in the multimedia presentation. Yet in the same experiment, student performance on comprehension and recall of presented material did not differ in interfaces with versus without an on-screen agent.

This result has been replicated (e.g., Moreno 2001; Craig et al. 2002), suggesting that the presence of an on-screen agent did not produce a split-attention effect. For example, Moreno (2001) found that students who were presented with an agent's image did not

perform differently on recall, problem solving, or rating the lesson than students not presented with the visual presence of the agent. However, Moreno and Mayer (2000a, b) showed that providing learners with personalized rather than neutral messages—whether provided by an on-screen agent or a narrator—produced better retention and problem-solving transfer. Personalization effects have been demonstrated in various learning settings (Moreno and Mayer 2004), and are hypothesized to be related to the creation of a social presence through which students feel heightened levels of identification with the agent, which in turn increases interest and learning (Reeves and Nass 1996; Hidi and Baird 1988).

Mayer's cognitive theory of multimedia learning and the other results presented in this literature review were derived from experiments carried out in laboratory settings. This study is primarily an exploration of applying cognitive theory to online learning in an authentic educational setting. Also, this study attempts to gain a deeper understanding of the factors that contribute to student use of online learning, and how and if this improves learning outcomes, with a specific focus on differences in learning related to seeing the image of a lecturer in a multimedia presentation. The study seeks to answer the following questions:

(1) Are there differences in student perceptions of instructional presentations delivered live and in different electronic formats?
(2) For multimedia presentations delivered online, what effect does the presence or absence of the video image of the lecturer have on students' reaction to and perception of its quality?
(3) Are there differences in performance on retention and transfer questions between students who viewed the presentation online and students who viewed the presentation live?
(4) What effect does the presence or absence of the lecturer's video image have on retention and transfer of material in online multimedia presentations?

Methods

The research team, working with instructional staff in the Physics department at a highly selective research university, designed a 20-min multimedia instructional presentation that explains the physics behind the thrill sensations one experiences when riding a roller coaster. The presentation builds on topics covered during the first 6 weeks of an undergraduate physics course intended for students not majoring in physics. The lecturer and research team used an iterative process in developing the presentation to ensure adherence to Mayer's seven design principles (2001). The lecturer was not involved in teaching the physics course from which we recruited study participants.

The finalized video version of the roller coaster presentation was prerecorded and then produced for online presentation using an open-source web-lecture archiving tool. The Web Lecture Archive Project (WLAP) (see http://www.wlap.org) is a lecture-capturing approach that was initially developed for the physics community, through a joint venture of the UM-ATLAS Collaboratory Project, the University of Michigan Media Union, and CERN, the European Laboratory for Particle Physics (Bousdira et al. 2001). Its goal is to implement an electronic archival system for slide-based presentations on the Internet. The system simultaneously captures the video image of the lecturer along with his or her electronic slide presentation, and has been used extensively in capturing important physics

lectures and creating training videos for physicists joining large-scale research projects. To encourage participation in the recording and archiving process the WLAP system archives and presents lectures in a way that does not require the presenter to modify his or her approach to the presentation.

To study the educational effect of various presentation formats, an experiment was developed that varied presentation mode (live versus online delivery) and format (varying whether the presentations delivered in online mode had a visible pedagogical agent). A live performance of the presentation given by the lecturer represents the experimental control group. One of the WLAP-produced online presentations includes the video image of the lecturer in addition to his voice and slide presentation (personalized video condition), while a second includes only the sound of the lecturer synchronized with the slides being presented (neutral video condition). This experimental design is important given potential trade-offs between splitting the attention of the learners between the presentation slides and the video image of the instructor (Moreno and Mayer 2000a, b) and the personalizing role on-screen agents can play in student learning (Moreno and Mayer 2004).

To conduct the experiment, students ($n = 280$) enrolled in the first of a two-course sequence introducing the fundamental concepts of physics were invited to participate. The course covers classical mechanics (laws of motion, force, energy, and power) and mechanical wave motion, including sound waves, and is offered primarily for non-major students wanting a quantitative introduction to the basic principles of physics without a high level of mathematical sophistication.

All 278 enrolled students were invited to participate in the study during a class session and through follow-up emails, and were randomly assigned to one of three groups: Personalized Video, Neutral Video, or Control Group. A total of 195 students (70%) participated in the study after several follow-up attempts, with participation rates being highest in the online conditions (personalized video 82% and neutral video 72%) as opposed to the live presentation (54%), presumably due to scheduling conflicts. This differential participation rate contributed to the different effective sample size across the three experimental groups that were created prior to the invitations. The online component of the study was run over 9 days, and the students were sent two follow-up reminders to encourage participation.

For the personalized video and audio group, the experiment was carried out entirely online at times and places chosen by the student participants rather than in a laboratory setting. This approach provided a more realistic setting in for how such lectures are likely to be accessed by students. The e-mail invitation contained a link that directed students to an informed consent form and an intake questionnaire that captured student background characteristics, demographic data, as well as information about the setting in which they were accessing the online instructional piece. Following the intake questionnaire, students were directed to a website where they viewed the presentation. The students completed an exit questionnaire following the presentation that included two retention questions, and one transfer question, and several questions aimed at measuring their perception of the quality of the presentation.

The control group watched a live lecture given by the same lecturer who made the pre-recorded online presentation, using the same slides. A member of the research team was present at the live lecture to verify that the content was the same, and to collect comparable study information on student backgrounds and educational outcomes from the live lecture participants.

In addition to the primary data analysis, we conducted two small focus groups with participants from the neutral and personalized video groups to inform us about additional aspects of the students' experiences, and to generate feedback to inform future research

efforts. Students from both video groups who had completed the on-line survey were offered a $25 incentive for their participation in the focus groups, which were held during the last week of the semester. During the focus group, participants were asked about their prior experience with and opinions about online learning, and whether they thought about the online presentation as a potential supplement or replacement for live lecturers. Participants were also asked about whether they felt they learned from the presentation and about how they navigated through the presentation.

Data Quality

Preliminary analyses of the quantitative data showed that the groups (neutral video, personalized video, and live control group) were similar in terms of most demographic and academic characteristics considered in the study.[1] There were, however, some differences across the groups, ostensibly due to differential patterns of non-participation. The live group tended to have more first-generation students (22%) compared to the personalized video (13%) or neutral video groups (4%), with means testing revealing that a significant difference existed between the live and neutral video groups ($F = 8.82$, df = 1, $p < .05$). Confidence in academic ability also differed, with the live group ($M = 3.02$) showing significantly more confidence than either the neutral video ($M = 2.76$; $F = 4.720$, df = 1, $p < .05$) and personalized video ($M = 2.77$; $F = 4.244$, df = 1, $p < .05$) groups.

One additional significant difference appeared between the two online groups on whether they liked the physics course they were taking ($F = 4.21$, df = 1, $p < .05$), and whether they felt their answers to the retention and transfer questions were based on prior knowledge rather than what they gained from the presentation ($F = 5.83$, df = 1, $p = .02$). In both cases, the neutral video group had a higher mean score on these items. Given the differences, these variables were used as controls in the multiple regression analyses presented below.

In consultation with the physics lecturer we developed two knowledge retention question and one transfer question that served as the learning outcome variables. The questions were designed to align with the content of the presentation and so that each could be graded using 3-point scoring rubrics discussed below. The scores on the two retention questions were combined, for a possible maximum of six points awarded for the retention scale ($\alpha = .84$).

The first retention question asked: *In your own words, what creates the thrill sensation one experiences when riding a roller coaster? Be as specific as possible.* Responses were evaluated using an established 3-point scoring rubric based on whether the student indicated the thrill was caused by change in perceived body weight (1 point) which occurred rapidly (1 point) in traveling from the top to the bottom of the hill (1 point). An example of a 3-point answer is: "The rapid changes in the sensation of your perceived weight. At the bottom of the hill of the rollercoaster your perceived weight is many times what it is perceived normally. At the top of the rollercoaster your perceived weight is basically 0." In contract, the student who responded "The rapid change in sensation of our body's weight, both increasing and decreasing" received only two points because they did not indicate that the rapid change occurred in traveling from the top to the bottom of the hill. Finally, an

[1] These included gender, academic status (first year to fourth year), prior math, academic confidence, physics confidence, whether they had a computer at their residence, had taken a distance-learning course, could fix a computer freeze, and the extent to which they use e-mail, surf the internet, had ridden a roller coaster, enjoy their physics course, see the course as relevant to their future careers, feel connected to their peers, and like to figure things out for themselves.

example of a one-point answer is: “The speed, visuals and perceived changes in weight.” Several respondents received 0 points.

The second retention question asked: *Explain as specifically as possible the difference between the equations* $N = mg - {}^{mv^2}\!/_r$ *and* $N = mg + {}^{mv^2}\!/_r$ *as they relate to the thrill experienced when riding a roller coaster. If you feel your previous answer captured this, you do not need to answer this question.* On this question, student responses were scored based on whether they related the equations to a person’s weight (1 point), identified the first equation with the force at the top of the hill (1 point) and identified the second equation with the force at the bottom of the hill (1 point). An example of a 3-point answer is: “N = mg + MV2/R is the feeling experienced at the bottom of a hill. It is your normal weight plus the forces from centripetal acceleration. N = mg − MV2/R is the feeling at the bottom of a hill, your weight minus centripetal forces from the rollercoaster.”

The transfer question asked: *How might you apply the ideas discussed in this presentation to the sensations experienced with riding in an elevator?* Student responses were scored based on whether included mention of perceived weight (1 point) due to acceleration (1 point) but that, unlike the rollercoaster scenario, centripetal acceleration was not applicable in the case of an elevator (1 point). An example of a 3-point answer is: “The same experience occurs in an elevator except you just have an additional linear acceleration negating or compounding your weight as opposed to a centripetal acceleration.”

Two members of the research team blind-scored all of the respondents’ questions and then met to discuss and resolve any disagreements in scoring before finalizing. When initial inconsistencies in scoring occurred, they were mainly due to small oversights in interpreting responses and were easily corrected. There were no multiple responses and no cases where the researchers could not agree on the scoring after a short discussion.

Because of the high correlations between many of the variables addressing student characteristics and reactions to the material presented, two factors were created as independent variables for a regression analysis: (1) academic confidence ($\alpha = .76$, marked by responses to three questions: “How confident are you in your ability to do well in physics?,” “How confident are you in your academic ability, generally?,” and “What grade to you expect to get in Physics 125?”), and (2) quality of presentation ($\alpha = .83$, marked by responses to three items: “I understood the professor’s explanations,” “Information in the slides was clear,” and “Professor’s voice was clear.”) The academic confidence factor was included on the assumption that a student’s confidence related to the subject matter might influence their engagement with the presentation, as well as their ability to successfully answer the retention and transfer questions. Perception of presentation quality was included for two reasons. First, it was important to have a general gauge of presentation quality since confusing or otherwise poor presentations can be inadvertently generated despite the application of design principles and use of external review. This variable also serves as an important control since the technology conditions of the study effectively present participants with a technologically transformed version of the same base presentation given to the live group, and this transformation, if poorly implemented, may yield negative student reactions and lower student performance.

Limitations

This study has several limitations. Although we had a live control group for this experiment, there were minor variations in the presentation that are to be expected between two offerings of a lecture. A member of the research team viewed the live presentation, and the

slides used were exactly the same as was the general content and spirit of the presentation. However, it was noted that during the live presentation the lecturer mentioned an elevator in his presentation, whereas this was absent from the online presentation. Specifically, the professor mentioned that he did an experiment where they measured the perceived weight change when riding in an elevator and established it to be 1.1 g's (a 10% increase over the weight due to gravity). In the live group, 10% of the respondents mentioned this example in their answer to the transfer question. Given that this represented extra help for the control (e.g., live presentation) group any effects related to transfer are likely to be smaller than they would have otherwise been.

Additionally, it is difficult to isolate the effects of the presentation on their transfer and retention scores versus the effect of their individual effort or prior knowledge despite controls for both attributes. During focus groups conducted with the video participants, several students indicated they were uninterested or unwilling to take notes while viewing the presentation because the presentation was not tied to any graded assessment, and they indicated they had difficulty concentrating for the length of time required of the presentation. Moreover, defining learning retention and transferability measures is problematic both in research and practice settings, which we addressed by working carefully with a physics faculty member to create the criterion measures that were ultimately used.

Results

Before addressing the central question of differences in educational outcomes across the different groups in the study, it is important to understand how students rated the different presentations. Table 2 shows the perceptions of and reactions to the presentations across the different modes. Students across all presentation modes felt the level of concepts presented was appropriate (rather than being too easy or advanced for students enrolled in the course from which participants were recruited), and that it was a quality presentation (overall mean of 5.67 on a scale where 7 was the highest quality presentation). Students who viewed the presentation live rated it as being significantly higher in quality ($p < .05$) than the video groups. Interestingly, though, there was substantial agreement ($M = 3.12$ on a 4-point scale) among those viewing the presentation via video that the format was just as effective as a live lecture would have been. Taken together, the first panel of Table 1 shows that most students thought the presentations had positive qualities, with little measurable difference across presentation formats. Students in the live presentation group did, however, believe that the instructor's explanations made more sense than did those in either of the video groups ($p < .05$).

Table 3 shows how students chose to view the online video presentations, which is important given that students in the online conditions chose when and where to view the video material. There were no significant differences between the viewing choices made by those the neutral video and personalized video groups. Most of the students listened to the presentation with computer speakers (as opposed to private headphones), and only one in twenty anticipated a problem concentrating in the presentation viewing location.

Importance of Professor's Image

The second research question is addressed in Table 4, which shows students' perceptions of the lecturer (or his image) during the presentation. There was a significant difference between the live and personalized video group in how frequently they looked at the

Table 2 Student perceptions of the presentation

Question	Means (standard deviations)			
	All students	Live presentation group	Personalized video group	Neutral video group
How would you rate the level of the concepts explained in the presentation?[a]	2.05 (.23)	2.04 (.28)	2.05 (.23)	2.04 (.21)
Rate the overall quality of this presentation on a scale of 1–7 (1 = lowest, 7 = highest)	5.67 (.90)	5.98[b] (.77)	5.61 (.83)	5.52 (1.01)
Level of agreement with the following statements[c]				
The professor's voice was clear throughout the presentation	3.79 (.48)	3.90 (.30)	3.74 (.50)	3.77 (.55)
The professor's explanations made sense to me	3.74 (.45)	3.90 (.30)[b]	3.66 (.51)	3.72 (.45)
The information presented in the slides was clear	3.81 (.42)	3.88 (.33)	3.74 (.50)	3.83 (.38)
Sometimes there was too much information presented in a single slide	1.95 (.74)	1.78 (.71)	2.04 (.73)	1.99 (.76)
I think this presentation was as effective as having a live lecture	3.12 (.82)		3.14 (.78)	3.09 (.87)
The device used to view the slides was easy to use	3.54 (.73)		3.49 (.68)	3.59 (.77)
Did you have technical difficulties in viewing the presentation?	.28 (.45)		.28 (.45)	.28 (.45)

[a] 1 = Too easy for students in this course, 2 = appropriate for students in this course, 3 = too advanced for students in this course

[b] Indicates a significant difference as measured by ANOVA, with post-hoc testing revealing that the live condition as the source of the difference

[c] 1 = Strongly disagree, 2 = disagree somewhat, 3 = agree somewhat, 4 = strongly agree

Table 3 How students viewed the online presentations

Question	Percentages		
	All online students	Personalized video group	Neutral video group
How students viewed the presentation			
Working on their own computer	81	79	83
Been in the location twice or more	93	93	93
Watched the presentation just once	95	95	94
Which of the following best describes the setting where you are right now?			
Room by myself	56	52	61
Room with others present	30	33	26
Computer lab with others present	13	13	12
Public place with others present	1	3	z

Note: z indicates less than 1

professor during the presentation (1 = never, 2 = occasionally, 3 = frequently) ($p < .04$). Specifically, the live group ($M = 2.80$) tended to look at the professor more than the personalized video group ($M = 2.29$). A cross-tabulation revealed that 80% of the live group looked at the professor frequently compared to 38% of the personalized video group.

Table 4 Student perceptions related to the professor's image

Question	Means (standard deviations)			
	All students	Live presentation group	Personalized video group	Neutral video group
How often did you look at the professor during the presentation[a,b]	2.49 (.60)	2.80 (.40)	2.29 (.63)	
Having the professor's image was distracting[c]	1.70 (.63)		1.70 (.63)	
I think this presentation would have been better with the professor's image[c]	2.83 (.82)			2.83 (.82)

[a] 1 = never, 2 = occasionally, 3 = frequently

[b] Indicates a significant difference as measured by ANOVA, $p < .05$

[c] 1 = strongly disagree, 2 = disagree somewhat, 3 = agree somewhat, 4 = strongly agree

While this suggests that students who are not looking at the lecturer as much might be spending a greater proportion of time focused on the slide-based content of the presentation than those viewing live presentations, this may not be the case of online students are multitasking to a greater degree. Students in the personalized video group disagreed with the notion that the professor's image was distracting ($M = 1.70$ on a four-point agreement scale), while students in the neutral video tended to agree that the presentation would be better had that been presented with a personalized version ($M = 2.83$). In terms of split-attention and persona considerations, the results seem to support the development of personalized videos as opposed to neutral ones on the basis of student reactions, though practical production concerns related to the capture of professorial images may make that relatively costly to undertake.

Analysis of Transfer and Retention Questions

Table 5 presents ANOVA results of the differences in learning outcomes across the three presentation formats which corresponds to our third research question. With respect to the video conditions, there were no significant differences between the neutral video and personalized video groups on either the transfer or the retention question, suggesting that the persona effects on student learning were not found in these data. However, expanding

Table 5 Analysis of Variance (ANOVA) results on retention and transfer questions

Treatment group	Mean	SD
Transfer question		
Neutral video ($n = 69$)	1.30	0.79
Video ($n = 76$)	1.37	0.83
Live ($n = 50$)	0.92	0.80
Two-tailed sig, $p < .01$		
Retention question		
Neutral video ($n = 69$)	3.51	1.59
Video ($n = 76$)	3.45	1.61
Live ($n = 50$)	3.70	1.31
Two-tailed sig, $p > .05$		

the comparison to include the live lecture performance provides evidence of significant differences on the transfer question between both the live and neutral video group ($F = 6.75$, df = 1, $p < .01$; moderate effect size, $d = .48$, $r = .23$) and the live and personalized video group ($F = 9.02$, df = 1, $p = .00$; moderate effect size, $d = .55$, $r = .27$). The live group ($M = .92$) scored significantly *lower* than the neutral video ($M = 1.30$) and personalized video group ($M = 1.37$). There were no statistical differences detected across groups for the retention question.

The main point of the roller coaster presentation was that acceleration causes an increase in the normal force and hence in the perceived weight of the person. A post-hoc analysis revealed that 50% of the personalized video group mentioned "acceleration" in their response, as did 38% of the neutral video group and 28% of the live. Chi Square test of independence revealed a relationship ($p < .05$) between treatment group and mentioning "acceleration." A smaller percentage of the live group (16%) used equations in their response compared to the neutral video (22%) or the personalized video (28%) group, but this difference was not significant.

Regression Results

Given the unexpected differences in the characteristics of students in each of the three experimental grouping despite our random assignment procedure, we conducted a regression analysis to control for these complicating variables and also included two additional ones (e.g., general level of technology use factor given the internet streaming used to deliver the video presentations, and rating of presentation quality) we felt might contribute to the extent to which students were able to retain and transfer the information presented in the lecture. The primary goal of these analyses is not to provide a complete explanatory model of student learning, but rather to control for known and reasonably expected influences that serve to complicate our interpretation of experimental group differences. These regression models were statistically significant for both dependent variables, and the results for individual variables are summarized in Table 6.

The overall model for the transfer questions was significant ($p < .01$), and explained 10.4% of the variance in the dependent variable. None of the control variables was determined to be statistically significant. The experimental group variable set revealed that

Table 6 Regression results

	Transfer question		Retention question	
	Beta	Sig.	Beta	Sig.
I like my Physics course	.034	.650	−.122	.091
Confidence in academic ability	.132	.083	.152	.041
First generation college student	−.029	.686	−.085	.227
Answers based mainly on prior knowledge	.139	.060	−.112	.118
Technological sophistication factor	−.082	.264	.108	.132
Perception of presentation quality	.141	.060	.263	.000
Neutral video presentation group	.282	.003	.015	.866
Personalized video presentation group	.363	.000	−.013	.888
Variance explained (R^2)	.104		.152	
Significance of equation	.010		<.000	

students in each of the video presentation groups had significantly higher scores on the transfer question that the control group, which is the omitted group in the regression analysis ($p < .01$), mirroring the ANOVA results presented in Table 3. Similarly, the regression results associated with the retention question were consistent with the ANOVA results, which indicated that there were no significant differences across the experimental groupings. Perception of presentation quality ($p < .001$) and confidence in academic ability ($p < .05$) were the only significant predictors of retention in the analysis.

Focus Groups

Most of the focus-group participants ($n = 8$) had previously taken classes that required homework to be submitted through the internet (web homework), had done research, and had accessed reading assignments and/or course syllabi online. However, none of the students in the focus groups had significant prior experience with either an online course or with a course that incorporated online instructional pieces such as the roller coaster presentation.

The majority of the participants felt that online instructional segments such as the roller coaster presentation could supplement or enhance but not replace lectures. In general, they felt the presentation gave them a more comprehensive understanding of the concepts, but they were unsure of whether this would be true if they were being introduced to new ideas rather than ones that had been covered previously. The participants were particularly concerned about the sustained attention this type of presentation requires because much of the information came from the professor's narrative. In general, the participants indicated they were easily distracted and tended to multi-task (check e-mail, do instant messaging, take phone calls) when doing work online. As such, they expressed a preference for downloading reading assignments rather than being required to watch presentations that require a greater degree of concentration.

Most participants believed that the online presentation went at a slower pace than the lecture and that this was helpful. One participant said he had difficulty with equations and that the visualizations in the online presentation helped him better understand the equations. The participants overwhelmingly agreed that they do significant work with equations in the physics course, and several felt that this type of instruction could be used to give deeper explanations of equations and would be more helpful than reading the textbook. There were conflicting views about whether students learned from the presentation or answered the retention and transfer questions based on prior knowledge. Although most expressed the positive aspects of taking notes, they were uninterested or unwilling to take notes while viewing the online presentation because the presentation was not tied to any graded assessment.

The participants in the personalized video focus group were lukewarm about whether the image of the professor enhanced the presentation, which they tended to think lacked "bells and whistles" and was not very interactive. The two members of the neutral video focus group stated that they would like to have seen the image of the professor. Most watched the presentation only once yet tended to back up to repeat slides. Technical problems of any nature were a source of frustration that raised concerns.

Discussion

Teachers and learners approach their interrelated tasks in a multitude of ways that are based both on their beliefs, previous experiences, and implicit and explicit understandings

of how cognitive development occurs. In this study we explored how cognitive theory and related principles of design articulated by Mayer (2001) might influence student learning if properly deployed by postsecondary faculty.

Our particular experiment focused on differences in learning related to seeing an image of a lecturer in a multimedia presentation. We compared a typical classroom presentation developed using Mayer's design principles with an equivalent set of media-based versions of the same presentation, as well as the relative effectiveness of producing media-based versions that are personalized with a synchronized video of the lecturer versus a more neutral format that is basically a narrated slide show of the lecture content. These are important considerations given potential learning tradeoffs related to splitting a learner's attention unnecessarily versus personalizing the experience as one might have in a traditional, live lecture, as well as the additional production complexities necessary to produce a personalized presentation.

This discussion begins with findings with respect to the neutral video and personalized video groups and the effect of seeing the image of the instructor in the online presentation. We then discuss results with respect to the differences in achievement on transfer questions between the live, neutral video, and personalized video groups. Finally, we present evidence about the quality of the online presentation that provide preliminary evidence of the effects of adhering to Mayer's (2001) design principles for multimedia presentation.

Video Groups: Effect of Seeing the Image of the Instructor

The results of this study serve as a replication in a more naturalistic setting of a finding by Andre et al. (1998), showing that the presence of a pedagogical agent may affect students' enjoyment of an online presentation but not the comprehension and recall of presented material. Specifically, in this study, there was no significant difference between the neutral video and personalized video groups on either the retention or transfer questions, suggesting that split-attention effect did not occur. Further, less than 10% of the personalized video group agreed that the professor's image was distracting, and the neutral video group tended to believe they would have learned more from the presentation if they could see the professor in addition to hearing his voice. Finding the professor's image not distracting is different than believing that the image actually enhanced the presentation. In fact, the participants in the personalized video focus groups were lukewarm about whether the image of the professor enhanced the presentation, which they in general felt lacked "bells and whistles" and was not very interactive.

These findings together have practical implications for faculty or staff making decisions about web-delivered instruction, as including the video image of the professor takes considerable effort to capture as well as additional bandwidth to deliver compared to presenting only a narrated slide show (2.5 times as much for this particular presentation), especially given that the personalized video may not affect achievement in terms of comprehension. As a next step, a study should be undertaken where students are exposed to online presentations of this sort over a longer period of time—at least the length of the semester—to explore the effects of the instructors' image.

Live Group and Personalized Video Group: Differences in Achievement on Transfer Question

The presence of a live control group resulted in interesting findings that suggest a direction for research aimed at answering the question posed by Meyer (2002)—namely, "Which

technology works with which students and which learning objective in which discipline and why" (p. vii). First, the live group ($M = .92$) scored significantly lower than the neutral video ($M = 1.30$) and personalized video group ($M = 1.37$) on the transfer question, while there was no significant difference between the groups on the retention question. In fact, controlling for a number of relevant explanatory variables yielded the same pattern of results, thus giving us more confidence in the results observed.

Second, the live group looked significantly more often at the professor than the personalized video group ($d = .96$, $r = .43$). And the live group tended to agree significantly more often that the professor's explanations made sense to them than did the neutral video ($d = .47$, $r = .23$) or the personalized video group ($d = .58$, $r = .28$). Finally, the personalized video group ($M = 2.04$) agreed significantly more often than the live group ($M = 1.78$) that the slides sometimes contained too much information. The effect size for this final result was small ($d = .36$, $r = .18$).

In combination, these results suggest to us that, while the professor's image was present for both the personalized video and live groups, the live group tended to focus more on what the professor was saying than the information contained in the slides. As a result, the information contained in the PowerPoint—the equations for Newton's second law—which formed the basis of the criteria for grading the transfer question, might have been more salient to the groups viewing the presentation online. This possibly explains the higher achievement by the personalized video group and the neutral video group on the transfer question.

This leads us to suggest that online presentations such as this might be particularly useful for disciplines that are "equation heavy." This belief is partially bolstered by a discussion in one of the focus groups where a student mentioned that the slides in the presentation helped him better understand the equations, to which there was general agreement. In addition, a post-hoc analysis showed that the live group less often mentioned "acceleration" or used equations in their transfer question response.

Effect of Mayer's Design Principles for Multimedia Presentations

This study is an initial exploration of applying Mayer's (2001) design principles to a more authentic setting and one that closely aligns with typical practice within postsecondary settings. Without a control group for presentation mode (e.g., before and after enhancement of the presentation using Mayer's principles), these results are at most suggestive that Mayer's design principles may be useful in the creation of high quality multimedia presentations. Participants who viewed the presentation online uniformly rated the presentation as of high quality, agreed that the information presented in the slides was clear, and disagreed that there was too much information presented in the slides. Moreover, the regression showed that the quality variable was the most significant predictor of retention scores. It should, of course, be noted that the students in the live presentation enjoyed the benefits of the effort to create a well-designed presentation intended for the video formats. And while Mayer's work holds great practical promise in increasing the quality of lecture-based presentations, more active pedagogies might be employed to enhance student learning not only in equation-heavy fields of study, but in the arts, humanities, social sciences, and professional fields (Bransford et al. 1999). Additional research, conducted across a range of practice settings, and also exploring other conceptualizations of the teaching and learning process and other approaches an technologies are needed, and would provide welcomed guidance to postsecondary instructors.

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